WHAT IS CLAIMED IS:

1. A longitudinally coupled multi-mode piezoelectric filter utilizing a piezoelectric stiffened effect, comprising:

a multilayer piezoelectric element, the multilayer piezoelectric element including:

at least four excitation electrodes arranged substantially parallel to one another, and

a plurality of piezoelectric layers each provided between adjacent ones of said at least four excitation electrodes and polarized in a direction that is substantially perpendicular to or substantially parallel to the excitation electrodes, wherein the multilayer piezoelectric element has first and second end surfaces opposing each other in the direction that is substantially perpendicular to the excitation electrodes;

a ground electrode provided on an outer surface of the multilayer piezoelectric element and electrically connected to a first group defined by at least two of the at least four excitation electrodes, the at least two of the excitation electrodes of the first group being selectively arranged in the direction in which the piezoelectric layers are provided;

an input electrode provided on the outer surface of the

multilayer piezoelectric element and electrically connected to a second group defined by at least one of the at least four excitation electrodes, the at least one of the excitation electrodes of the second group being arranged toward the first end surface and being other than the excitation electrodes of the first group; and

an output electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a third group defined by at least one of the excitation electrodes, the at least one of the excitation electrodes of the third group being arranged toward the second end surface and being other than the excitation electrodes of the first group;

wherein an input signal applied between the input electrode and the ground electrode causes vibration of different order modes to be excited and coupled, such that an output signal is extracted between the output electrode and the ground electrode.

2. A longitudinally coupled multi-mode piezoelectric filter according to claim 1, wherein the different order modes are an nth harmonic and an (n-1)th harmonic, n being an integer equal to or greater than 3.

3. A longitudinally coupled multi-mode piezoelectric

filter according to claim 1, wherein the different order modes are an nth harmonic, an (n-1)th harmonic, and an (n+1)th harmonic, n being an integer equal to or greater than 3.

4. A longitudinally coupled multi-mode piezoelectric filter according to claim 1, wherein at least one of the first group of the excitation electrodes is arranged between two closest excitation electrodes, one of which belonging to the second group and the other belonging to the third group.

5. A longitudinally coupled multi-mode piezoelectric filter according to claim 1, further comprising:

reflection layers respectively coupled to the first and second end surfaces of the multilayer piezoelectric element and made of material having a second acoustic impedance $Z_2$ that is smaller than an acoustic impedance $Z_1$ of piezoelectric material that defines the piezoelectric layers of the multilayer piezoelectric element; and

holding portions respectively coupled to outer surfaces of the reflection layers and made of material having a third acoustic impedance $Z_3$ that is greater than the second acoustic impedance $Z_2$, the outer surfaces of the reflection layers opposing the first and second end surfaces to which the reflection layers are coupled.

6. A longitudinally coupled multi-mode piezoelectric filter which utilizes a piezoelectric stiffened effect, comprising:

a multilayer piezoelectric element, the multilayer piezoelectric element including:

at least four excitation electrodes arranged substantially parallel to one another, and

a plurality of piezoelectric layers each provided between adjacent ones of said at least four excitation electrodes and polarized in a direction that is substantially perpendicular to the excitation electrodes, wherein the multilayer piezoelectric element has first and second end surfaces opposing each other in the direction that is substantially perpendicular to the excitation electrodes, and has first, second, third, and fourth side surfaces extending between the first and second end surfaces in a longitudinal direction of the piezoelectric element;

a ground electrode provided on an outer surface of the multilayer piezoelectric element and electrically connected to a first group defined by at least two of the at least four excitation electrodes, the at least two of the at least four excitation electrodes of the first group being selectively arranged in the direction in which the piezoelectric layers are provided;

an input electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a second group defined by at least one of the at least four excitation electrodes, the at least one of the excitation electrodes of the second group being arranged toward the first end surface and being other than the excitation electrodes of the first group; and

an output electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a third group defined by at least one of the excitation electrodes, the at least one of the excitation electrodes of the third group being arranged toward the second end surface and being other than the excitation electrodes of the first group;

wherein an input signal applied between the input electrode and the ground electrode causes excitation and coupling of vibration of different order length modes, such that an output signal is extracted between the output electrode and the ground electrode.

7. A longitudinally coupled multi-mode piezoelectric filter according to claim 6, wherein the different order modes are an nth harmonic and an (n-1)th harmonic, n being an integer equal to or greater than 3.

8. A longitudinally coupled multi-mode piezoelectric filter according to claim 6, wherein the different order modes are an nth harmonic, an (n-1)th harmonic, and an (n+1)th harmonic, n being an integer equal to or greater than 3.

9. A longitudinally coupled multi-mode piezoelectric filter according to claim 6, wherein at least one of the first group of the excitation electrodes is arranged between two closest excitation electrodes, one of which belonging to the second group and the other belonging to the third group.

10. A longitudinally coupled multi-mode piezoelectric filter according to claim 1, further comprising:

reflection layers respectively coupled to the first and second end surfaces of the multilayer piezoelectric element and made of material having a second acoustic impedance $Z_2$ that is smaller than an acoustic impedance $Z_1$ of piezoelectric material that defines the piezoelectric layers of the multilayer piezoelectric element; and

holding portions respectively coupled to outer surfaces of the reflection layers and made of material having a third acoustic impedance $Z_3$ that is greater than the second acoustic impedance $Z_2$, the outer surfaces of the reflection layers opposing the first and second end surfaces to which

the reflection layers are coupled.

11. A longitudinally coupled multi-mode piezoelectric filter which utilizes a piezoelectric stiffened effect, comprising:

a multilayer piezoelectric element, the multilayer piezoelectric element including:

at least four excitation electrodes arranged substantially parallel to one another, and

a plurality of piezoelectric layers each provided between two adjacent excitation electrodes and polarized in a direction that is substantially perpendicular to the excitation electrodes, wherein the multilayer piezoelectric element has first and second end surfaces opposing each other in a direction that is substantially perpendicular to the excitation electrodes, and has first, second, third, and fourth side surfaces extending between the first and second end surfaces extending in a thickness direction of the piezoelectric element;

a ground electrode provided on an outer surface of the multilayer piezoelectric element and electrically connected to a first group defined by at least two of the at least four excitation electrodes, the at least two of the excitation electrodes of the first group being selectively arranged in the direction in which the piezoelectric layers

are provided;

an input electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a second group defined by at least one of the at least four excitation electrodes, the at least one of the excitation electrodes of the second group being arranged toward the first end surface and being other than the excitation electrodes of the first group; and

an output electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a third group defined by at least one of the at least four excitation electrodes, the at least one of the excitation electrodes of the third group being arranged toward the second end surface and being other than the excitation electrodes of the first group;

whereby an input signal applied between the input electrode and the ground electrode causes excitation and coupling of vibration of different order thickness extensional modes, such that an output signal is extracted between the output electrode and the ground electrode.

12. A longitudinally coupled multi-mode piezoelectric filter according to claim 11, wherein the different order modes are an nth harmonic and an (n-1)th harmonic, n being an integer equal to or greater than 3.

13. A longitudinally coupled multi-mode piezoelectric filter according to claim 11, wherein the different order modes are an nth harmonic, an (n-1)th harmonic, and an (n+1)th harmonic, n being an integer equal to or greater than 3.

14. A longitudinally coupled multi-mode piezoelectric filter according to claim 11, wherein at least one of the first group of the excitation electrodes is arranged between two closest excitation electrodes, one of which belonging to the second group and the other belonging to the third group.

15. A longitudinally coupled multi-mode piezoelectric filter according to claim 11, further comprising:

reflection layers respectively coupled to the first and second end surfaces of the multilayer piezoelectric element and made of material having a second acoustic impedance $Z_2$ that is smaller than an acoustic impedance $Z_1$ of piezoelectric material that defines the piezoelectric layers of the multilayer piezoelectric element; and

holding portions respectively coupled to outer surfaces of the reflection layers and made of material having a third acoustic impedance $Z_3$ that is greater than the second acoustic impedance $Z_2$, the outer surfaces of the reflection

layers opposing the first and second end surfaces to which the reflection layers are coupled.

16. A longitudinally coupled multi-mode piezoelectric filter, comprising:

a multilayer piezoelectric element, the multilayer piezoelectric element including:

at least four excitation electrodes arranged substantially parallel to one another, and

a plurality of piezoelectric layers each provided between adjacent ones of the at least four excitation electrodes and polarized in a direction that is substantially parallel to the excitation electrodes, wherein the multilayer piezoelectric element has first and second end surfaces opposing each other in a direction that is substantially perpendicular to the excitation electrodes, and has first, second, third, and fourth side surfaces extending between the first and second end surfaces in a thickness direction of the piezoelectric element;

a ground electrode provided on an outer surface of the multilayer piezoelectric element and electrically connected to a first group defined by at least two of the at least four excitation electrodes, the at least two of the excitation electrodes of the first group being selectively arranged in the direction in which the piezoelectric layers

are provided;

an input electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a second group defined by at least one of the at least four excitation electrodes, the at least one of the excitation electrodes of the second group being arranged toward the first end surface and being other than the excitation electrodes of the first group; and

an output electrode provided on the outer surface of the multilayer piezoelectric element and electrically connected to a third group defined by at least one of the at least four excitation electrodes, the at least one of the excitation electrodes of the third group being arranged toward the second end surface and being other than the excitation electrodes of the first group;

wherein an input signal applied between the input electrode and the ground electrode causes excitation and coupling of vibration of different order thickness shear modes, such that an output signal is extracted between the output electrode and the ground electrode.

17. A longitudinally coupled multi-mode piezoelectric filter according to claims 16, wherein the different order modes are an nth harmonic and an (n-1)th harmonic, n being an integer equal to or greater than 3.

18. A longitudinally coupled multi-mode piezoelectric filter according to claim 16, wherein the different order modes are an nth harmonic, an (n-1)th harmonic, and an (n+1)th harmonic, n being an integer equal to or greater than 3.

19. A longitudinally coupled multi-mode piezoelectric filter according to claim 16, wherein at least one of the first group of the excitation electrodes is arranged between two closest excitation electrodes, one of which belonging to the second group and the other belonging to the third group.

20. A longitudinally coupled multi-mode piezoelectric filter according to claim 16, further comprising:

reflection layers respectively coupled to the first and second end surfaces of the multilayer piezoelectric element and made of material having a second acoustic impedance $Z_2$ that is smaller than an acoustic impedance $Z_1$ of piezoelectric material that defines the piezoelectric layers of the multilayer piezoelectric element; and

holding portions respectively coupled to outer surfaces of the reflection layers and made of material having a third acoustic impedance $Z_3$ that is greater than the second acoustic impedance $Z_2$, the outer surfaces of the reflection

layers opposing the first and second end surfaces to which the reflection layers are coupled.